

Features

RISKS ENDEMIC TO LONG-HAUL TRUCKING IN NORTH AMERICA: STRATEGIES TO PROTECT AND PROMOTE DRIVER WELL-BEING

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ABSTRACT

Long-haul truck drivers in North America function in a work context marked by excess physical and psychological workload, erratic schedules, disrupted sleep patterns, extreme time pressures, and these factors' far-reaching consequences. These work-induced stressors are connected with excess risk for cardiometabolic disease, certain cancers, and musculoskeletal and sleep disorders, as well as highway crashes, which in turn exert enormous financial burdens on trucking and warehousing companies, governments and health-care systems, along with working people within the sector. This article: 1) delineates the unique work environment of long-haul truckers, describing their work characteristics and duties; (2) discusses the health hazards of long-haul trucking that impact drivers, the general population, and trucking enterprises, examining how this work context induces, sustains, and exacerbates these hazards; and (3) proposes comprehensive, multi-level strategies with potential to protect and promote the health, safety, and well-being of truckers, while reducing adverse consequences for companies and highway safety.

Keywords: long-haul truckers, work environment, excess driver morbidity, highway safety, prevention and protection strategies

While the trucking and warehousing sectors of industrialized nations are similar in many ways [1, 2], the health disparities affecting North American long-haul trucking [3] warrant particular attention. Long-haul trucking has been recognized as an occupation that is disproportionately detrimental—when compared to other occupations—to the health, safety, and well-being of drivers [4]. Tractor-trailer drivers function in a work context marked by high physical and psychological workload, erratic schedules, time pressures, disrupted sleep patterns, and resultant ramifications [5]. These stressors have been linked with truckers' excess cardio-metabolic disease, certain types of cancer, and musculoskeletal and sleep disorders, along with highway crashes that carry serious repercussions not only for truckers but also for the general population [6-8]. These, in turn, exert financial burdens not only on trucking and warehousing companies, governments, and health-care systems, but also on working people in the sector and the general population [9, 10]. In this article, we: 1) delineate the unique work environment of North American long-haul truckers and describe their work characteristics and duties; 2) discuss the health hazards of long-haul trucking that impact drivers, the general population and trucking enterprises, and also examine how this work context induces, sustains, and exacerbates these endemic hazards; 3) review failures of the industry and unions representing long-haul drivers to address the need to reduce exposures and morbidities; and 4) propose comprehensive strategies with potential to protect and promote the health, safety, and well-being of truckers, while reducing adverse consequences for drivers, companies, and the public at large.

WORK ENVIRONMENT AND TASKS OF LONG-HAUL TRUCKERS

The work environments in which North American long-haul truck drivers operate, and the specific tasks that constitute their job duties, are largely unique compared to those of other occupations.

Trucking Work Environment

Nearly 5 million North American long-haul truck drivers are susceptible to an array of hazards that are predominantly attributable to a multi-level work context that is detrimental to their health, safety, and overall well-being [11]. The structure and organization of long-haul trucking operations reveal a competitive sector with supply-chain features that translate into intense scheduling and delivery pressures exerted by subcontractors, shippers and consignees, and mile-based driver compensation systems that add even more pressure on drivers by linking their earnings to driving longer and harder [5, 12, 13]. The foregoing characteristics are embedded within government-mandated hours-of-service (HOS) policies that determine drivers' work and rest hours, and deregulation, which has contributed to the overall deterioration of truckers' work conditions [11]. The broad context of

long-haul trucking is replete with multiple, interconnected stressors for drivers that not only exacerbate endemic hazards associated with the North American transport sector itself, but define driver health and highway safety and have far-reaching ramifications for the corporate bottom line [5].

Key among these stressors are: physical and psychological workload and fatigue; high demands for continual mental alertness despite monotonous tasks; pressures due to tight-running schedules and just-in-time deliveries; exposure to physical and chemical hazards; irregular shiftwork leading to disrupted sleep patterns and chronic sleep deprivation; scarcity of workplace resources to promote good health; sedentary work conditions; low job control and job satisfaction; extended social isolation; and work-life conflicts [14]. Strains endemic to this profession, whether long-standing or acute, have led to the characterization of post-deregulation long-haul trucking in North America as “sweatshops on wheels” [12].

Tasks of Long-Haul Truckers

The duties of long-haul truckers in North America are heterogeneous. Truckers can be broadly classified into company drivers, owner-operators, and independent contractors. Trucking companies are typically designated as either “for-hire service,” which is the primary segment of the trucking industry, or private carriers, and operate a variety of routes, including local (short-haul), regional, and over-the-road (long-haul) routes. Carriers might transport a variety of freight, including refrigerated, specialized, and intermodal freight (moving containers from seaports or rail yards), and run either truckload or less-than-truckload freight. Truckload freight typically involves longer distances and is usually moved directly from shipper to consignee, while less-than-truckload freight must be consolidated, hauled, and distributed by the carrier. This is usually done using a “hub-and-spoke” system, where freight is unloaded and reloaded at centrally located terminals and distributed from there to outlying locations. Less-than-truckload freight may also include inter-city freight, which resembles truckload freight in that it is moved directly from shipper to consignee.

Unique to the North American long-haul trucking industry are the array and characteristics of worksites. Trucking terminals, warehouses, truck stops, rest areas, highway on- and off-ramps, and truck cabs are among these worksites and represent settings in which drivers spend significant amounts of their driving as well as non-driving work hours. Also unique to trucking is the fact that these worksites represent “home” for regional and over-the-road drivers who do not return to their homes for extended periods of time, reaching several months at times. In fact, there is a segment of truck drivers for whom the truck cab represents their sole residence because maintaining a home or apartment that remains unused is not considered cost-efficient. Due to the scale of distances traveled in North America, unlike more traditional occupations, long-haul truckers are away from home for extended periods of time (i.e., more than 85% spend more than 17 days on the road monthly)

[11]. The recent proliferation of global positioning system (GPS) fleet-tracking has placed further constraints on the latitude drivers have in their occupational decision-making, especially in terms of trip planning and rest and driving periods, resulting in further escalation of the endemically high job strain of the profession [15, 16]. These devices have also been cited by the Owner-Operator Independent Driver Association as facilitating harassment of drivers by employers [17].

Driver activities are strictly monitored by the use of logbooks, which may be maintained on paper or electronically. For logging purposes, activities are labeled as driving, on-duty but not driving, sleeper berth, and off-duty but not in sleeper berth. Per HOS regulations, long-haul truckers may not drive more than 11 hours without taking 10 consecutive hours off-duty (combined sleeper berth and off-duty activities in logbooks), they may not drive beyond the 14th consecutive hour after coming on duty after their last 10 consecutive hours off-duty, and they may not be on-duty (combined driving and on-duty activities in logbooks) more than 60 hours in any consecutive 7-day period or 70 hours in any consecutive 8-day period (the 60/70-hour limit) [18]. One important stipulation is that, with the use of a “restart,” drivers can drive up to 80 hours or more each week. A “restart” occurs following 34 consecutive hours off-duty. Drivers are further required to take a 30-minute off-duty period within each 8 hours of on-duty time, which does not count against their 60/70-hour limit [18]. The 30-minute off-duty provision further strains drivers’ available time to drive, as the 14-hour provision is not extended to accommodate these breaks [18]; thus, drivers’ earning potentials are diminished. Circumvention of HOS rules is commonplace, as many drivers keep multiple sets of logbooks in case they are inspected by authorities while driving in violation of these rules, and in the case of electronic logbooks may unplug their systems for brief periods [15, 19].

Drivers are paid based on activity, which may come in a number of forms: by the mile (most prevalent), hourly, by the load, as a percentage of revenue; as well as loading/unloading pay, and detention pay if they are delayed by the shipper or consignee. Following the 1980 deregulation of the U.S. trucking industry, which has equally impacted Canadian and Mexican long-haul truckers who drive in the United States, the overall level of driver compensation has decreased [12]. Today’s drivers are forced to push themselves harder and drive longer hours to make a living, which regularly results in higher job strain, increased stress, and a plethora of negative health and safety outcomes [20]. The pressure to “make ends meet” often translates into increased violations of HOS rules, hence sacrificing safety and placing the motoring public at large at greater risk [21].

Any number of duties may fall within the purview of truckers, depending on what type of driver they are, what routes they run, and what type of freight their company hauls. Besides driving, truckers are required to conduct daily pre-/post-trip equipment inspections, which count against their available on-duty time each day; complete paperwork (e.g., logbooks, fuel records, trip receipts, inspection forms, and bills of lading); and maintain their equipment. They may couple and

uncouple the tractor and trailer; load and unload their cargo; complete minor maintenance on their equipment; refuel their tractors and, in the case of refrigerated trailers, maintain constant vigilance to assure the continuous operation of refrigeration to avoid spoiling of perishables; keep equipment clean by going through truck washes; secure cargo using wood blocks, load straps, or bars; maintain regular contact with supervisors or dispatchers; and obtain pickup or delivery verification or collect payment for goods delivered and delivery charges. When hauling hazardous materials, drivers are required to take additional action to monitor the safety of their freight. If drivers are responsible for loading and unloading freight, this may require the operation of equipment such as pallet jacks or forklifts; alternatively, drivers may be responsible for hiring, paying, and completing paperwork for lumpers, who load and unload freight.

HAZARDS FOR LONG-HAUL TRUCKERS AND THE GENERAL POPULATION

Programs to prevent injury and illness or to advance health and well-being, opportunities for healthful foods and physical activity, and health risk appraisals for endemically and chronically overstressed and excessively fatigued long-haul truckers in North America are currently minimal at best [22]. The highly stress-inducing and obesogenic work context of long-haul trucking, which has been characterized as a healthy-living desert [11, 14, 20], exacerbates the health problems of truckers, thus jeopardizing highway safety for the general motoring public [23]. Key hazards of long-haul trucking in North America involving truckers and trucking firms, the general population, governments, insurance companies, and health systems, fall into three broad categories: 1) strains associated with the physical and psychological workload of the job; 2) strains associated with chemical exposures; and 3) subsequent financial strains for companies and governments.

Strains Associated with the Physical and Psychological Workload of Long-Haul Trucking

The multiple physical and psychological strains associated with the long-haul trucking profession impact the health and well-being of drivers. These impacts often manifest in multiple ways, often simultaneously, and can disrupt the physical and psychological health of professional drivers.

Cardiometabolic Disease

Poor eating options and sedentary work have resulted in combined overweight and obesity rates among truckers that are about 15 percent higher than those of the general population (with combined overweight and obesity rates ranging from 56-92%) [7, 11]. Thirty-two percent of long-haul truckers are obese (the highest

prevalence among all occupations) [24], about 50 percent in the 45-64 age group have a body mass index (BMI) greater than 30 (nearly double the percentage in the general population) [25, 26], and the average driver's weight exceeds 240 pounds [27]. These strains, exacerbated by work-induced, chronically elevated psychological distress, are implicated in disproportionately high rates of hyperlipidemia (45-63%); hypertension (32-54%); cardiovascular disease; and intertwined diabetes, insulin resistance, and metabolic syndrome comorbidities (14%) [7, 8, 20, 28]. In a recent study, 85 percent of truckers mentioned cardiovascular disease or diabetes among their top health concerns, and about 90 percent of these drivers are on one or more medications for blood pressure, diabetes, cholesterol, or cardiovascular disease [11]. (See also below for how chemical exposures affect cardiometabolic health.)

Musculoskeletal Disorders

As the result of prolonged sitting and long workdays, combined with detrimental workplace ergonomics (e.g., truck cab discomfort, loading/unloading heavy cargo, and whole-body vibration) and overall strenuous job duties often involving overexertion, slips, trips, and falls, and exacerbated by high BMIs and driving stress, long-haul truckers sustain injuries leading to neck, lower-back, and sciatic pain, sprains and strains, degenerative spine shifts, and a variety of other spinal disorders [7, 20, 29, 30]. As a result, long-haul truckers account for more than 8 percent of all work-related musculoskeletal disorders. The use of Schedule II drugs (substances which are legally regulated and controlled) by drivers to alleviate distress caused by these disorders, and the impact of the consumption of these drugs on driving performance [31], may prompt the Federal Motor Carrier Safety Administration to expand drug testing to include these substances.

Psychiatric and Mental Health Disorders

Physically and psychologically draining work hours, excessive and chronic fatigue, disrupted sleep patterns, financial and time pressures, low job-decision latitude and control, low job satisfaction, low social support, low mental stimulation, and social isolation have taken their toll on the health of long-haul truckers [5]. These work strains often result in burnout, anxiety, distress, mental fatigue, and depression, which in turn frequently lead back to elevated levels of work-related stress that have far-reaching ramifications for drivers' overall well-being and also for highway safety [7, 19, 32, 33]. Increases in cortisol, adrenaline, and norepinephrine in the bloodstream caused by heightened stress—highly prevalent among long-haul truckers—have been shown to weaken the immune system while increasing blood flow, inducing wear and tear of coronary arteries, and leading to cardiovascular morbidities [34]. Not surprisingly, the proportion of commercial drivers in North America experiencing job strain (40%) is more than double that of workers in other sectors (18%) [35], and this anxiety is probably exacerbated by

the highly regulated nature of the industry, as well as by pressures from monitoring by electronic on-board recorders and ever-tighter medical standards that threaten driver disqualification. Because anxiety reduces peripheral stimuli detection and increases distraction, occupational stress results in task distractibility and has been associated with higher incidence of accidents among drivers [36, 37].

Sleep Disorders, Crashes, Disability, and Highway Safety

Fragmented and erratic work shifts, frequently disrupted circadian rhythms and insufficient sleep, sleep apnea (for which about 70% of long-haul truckers are at high risk), and other sleep disorders and consequential excessive daytime sleepiness, can have significant negative impacts on long-haul truckers' mental and physical health, thereby increasing the need for health-care services, and may even result in injury and death to self and others [7, 20, 38]. Within the transportation sector, truck drivers and driver/traveling sales workers had fatality rates of 22.1 per 100,000 workers in 2012, compared to only 3.2 per 100,000 workers for the general workforce during that same time period; further, heavy and tractor-trailer truckers account for 13 percent of all fatal occupational injuries [4]. Productivity pressures, such as mile-based compensation, further compromise safety by encouraging excessive driving speed and working when fatigued [33]. Truckers account for 15 percent of fatalities and consistently rank among the top three occupations in nonfatal injuries/illnesses, while obese truckers and those with sleep disorders have two-fold higher crash rates [21, 23], with the share of truck crashes attributable to trucker somnolence estimated to be as high as 20 percent [27, 36]. Despite the sparseness of systematic data, there is evidence to suggest that combined work-related comorbidities (e.g., cardiovascular disease, sleep disorders) and modifiable work-exacerbated risk factors (e.g., poor diets) could significantly influence accident rates [7, 10]. Finally, fatal work injuries in private truck transportation rose by 14 percent in 2011, surpassing even the construction sector, which is often associated with such injuries [39].

Work-Induced or -Exacerbated Behavioral Risks

The social isolation, monotony, excess fatigue, stress, and pronounced depression that truckers experience often facilitate or exacerbate substance use (e.g., tobacco, alcohol, drugs), sexual risk-taking (e.g., multiple/casual sex contacts on the road), and gambling, among other behavioral risk patterns [40]. In diverse trucking milieus in several U.S. states, small proportions of truckers were found to engage in risk-laden multiple and concurrent sex transactions with female sex workers, other women (e.g., employees at truck stops, casual acquaintances), and men who have sex with men and who cruise specifically for truck drivers (often referred to as "truckchasers"); often combined with use of amphetamines, cocaine, crack, speed, and marijuana to stay awake during long drives, to relax at the end of exhausting days, or to party during downtime, particularly in inner-city areas

[41-44]. These combined behaviors result in sexually transmitted infections. Long-haul truckers at various New Mexico and inner-city Atlanta trucking milieus were found positive for hepatitis C virus (8.5%, 10%), antibody to hepatitis B core antigen (a marker of acute, chronic, or resolved hepatitis B infection; anti-HBc) (10.4%, 1.7%), chlamydia (1.3%, 1.7%), gonorrhea (0.2%, 1.7%), syphilis (0.2%, 3.3%), and human immunodeficiency virus (HIV, 0.2%, 3.3%), respectively [45, 46]. These statistics far exceed infection rates in the general population for hepatitis C (0.0004%), hepatitis B (0.0009%), chlamydia (0.46%), gonorrhea (0.1%), syphilis (0.015%), and HIV (0.016%) [47-49].

Strains Associated with Chemical Exposures of Long-Haul Trucking

Trucking, through both driving and engine idling, is the main source of detrimental transport emissions in North America, including carbon monoxide, nitrogen oxides, and particulate matter. Idling in particular results in significant air pollution impacts—178,000 metric tons of nitrogen oxides, 4,900 metric tons of particulate matter, and 9.7 million metric tons of carbon dioxide are emitted from trucks each year [50]. Because a vast majority of trucks use diesel fuel, diesel exhaust represents one of the most common toxicants to which drivers are exposed. The Environmental Protection Agency estimates that truck exhaust accounts for 20 percent of all vehicle-produced microscopic soot and 30 percent of all smog-causing chemicals in the United States [51]. Chemical exposures of truckers in truck cabs, highways, trucking terminals, and warehouses have been associated with pulmonary comorbidities and various types of cancer, and have significant ramifications for drivers' cardiometabolic health [52].

Pulmonary Comorbidities

Long-term exposure, often including some acute exposures, to solid and gaseous components of diesel-exhaust fumes (a complex mixture of toxic compounds), as well as other pollutants (e.g., dust, other toxic fumes), have been connected to a wide variety of deleterious respiratory effects [53]. Wheezing, aggravated asthma, allergic inflammations, bronchitis, pneumonia, emphysema, and chronic obstructive pulmonary disease are among the most prevalent respiratory and pulmonary morbidities among truckers, dockworkers, and mechanics [54], as well as residents along trucking routes [55]. In a prospective mortality study of 3,392 professional drivers, truckers showed excess deaths from bronchitis, emphysema, and asthma (standardized mortality ratio (SMR) = 143, $p < 0.05$) [56]. Furthermore, acute coronary syndrome and other thrombotic effects have been associated with acute disease exhaust exposure [57, 58]. After controlling for smoking, long-haul truckers who were chronically exposed to diesel exhaust particles reported higher incidence of ischemic heart disease [59].

Cancer

In June 2012, the International Agency for Research on Cancer (IARC) classified diesel engine exhaust as carcinogenic to humans based on evidence “. . . that exposure is associated with an increased risk for lung cancer.” [60, 61], and diesel exposures have been connected with various types of cancer among long-haul truckers, such as occupational bladder cancer, lung cancer, prostate cancer, stomach cancer, and ovarian cancer among female drivers [62-65]. Although these risks are undeniable [65], U.S. policy-makers persist on questioning causal connections between diesel exposure and cancer, as well as the relationship between work-related economic pressures and demonstrated and reported occupational safety and health outcomes. Primary reasons for questioning causation rest on confounders such as synergistic effects of other pollutants (e.g., smoking prevalence among truckers), inconclusive research due to methodological shortcomings and deficient data, and the long latency period of most cancers [18].

Financial Burden for Truckers, Trucking and Insurance Companies, Governments, and Health Systems

These work-induced trucker comorbidities have, along with their ramifications for highway safety, far-reaching financial repercussions for drivers themselves, trucking companies, insurance companies, governments, and broader health systems. The financial burden of reduced workforce productivity (particularly in the form of absenteeism and “presenteeism,” or being present at work but not being productive), excess driver turnover (considering that nearly 40% of new drivers quit within their first 90 days), skyrocketing accident insurance and health-care costs, elevated workers’ compensation claims, and lost-time injuries carry an unbearable burden for transport and warehousing enterprises [9, 14, 22]. The Department of Labor has estimated that absenteeism and labor turnover account for 25 percent of trucking companies’ total budgets [36]. One study examined annual health-care costs over two years and found that these costs for obese drivers reached \$1,944, nearly twice that of normal weight drivers, whose annual healthcare costs were about \$1,131 [66]. A similar pattern is found across the U.S. workforce in general: total combined annual costs of absenteeism and medical expenditures for men increase from \$175 for those with BMIs of 25-29.9 to \$2,027 for those with BMIs of 40 or above [67]. As a result, insurance deductibles and out-of-pocket costs to truckers and their employers are 40 to 70 percent higher than those in other industries [68]. The combination of this excess morbidity of truckers and its impact on the ability of drivers to safely operate a commercial motor vehicle, often leads to medical disqualification from operating a commercial motor vehicle, and, although exact figures are not available, appears to diminish life expectancy [7, 69].

MEASURES TO PROTECT AND PROMOTE LONG-HAUL TRUCKER HEALTH AND HIGHWAY SAFETY

Given the numerous occupational strains and hazards that long-haul truck drivers encounter, and the resulting negative impacts that affect multiple stakeholders, strategies to protect and promote driver health are crucial. Unfortunately, with a few exceptions, such efforts are generally not in accord with the degree of risk endemic to the long-haul trucking profession.

The Current State of Driver Health Protection

The U.S. Department of Labor Occupational Safety and Health Administration (OSHA) regulates driver health, and offers information on topics such as walking and working surfaces, means of egress, hazardous materials, and personal protective equipment [70]. In addition, 25 states have OSHA-approved state plans that are developed by individual states but are approved and monitored by OSHA [71]. Individual companies, however, often take the lead in driver health protection. Larger companies dedicated to driver health, with more structured operations, often tend to have more resources to dedicate to driver safety and usually have higher safety performance than smaller companies [72]. In addition to size, the length of time a company has been in operation is related to safety. Newer companies often have poorer safety records, which may be attributed to their lack of familiarity with safety regulations and procedures [72]. Newer companies may also lack the requisite attitudes, knowledge, or skills to operate as safely as the more established companies [72]. In 2009 the federal regulatory agency for the trucking industry, the Federal Motor Carrier Safety Administration (FMCSA) heightened the safety requirements for motor carriers in an attempt to combat these safety shortcomings [72].

The Department of Transportation has most of the jurisdiction in issues involving driver health and safety. This regulatory body includes regulations under Title 49 of CFR 391 about certain aspects of driver health, including driver fitness, medical qualifications, and suitability to drive [9]; however, regulations which may be helpful in protecting drivers from the multiple adverse impacts associated with their profession and promote driver well-being are not explicitly stated in these regulations. Although OSHA could potentially play a role in protecting and promoting driver health and safety, its focus in this realm pertains primarily to worksites such as warehouses, docks, construction sites, and other places truck drivers go to deliver and pick up loads [73]. Furthermore, OSHA's ability to impact other areas of driver health and safety is greatly limited by the Occupational Safety and Health Act of 1970, Section 4(b)(1), which states that, "Nothing in this Act shall apply to working conditions of employees with respect to which other Federal agencies . . . exercise statutory authority to prescribe or enforce standards or regulations affecting occupational safety and health" [73]. Therefore, despite limited union representation within the trucking industry [74], unionization is an important factor in the extent of driver health protection.

Trucking unions, such as the International Brotherhood of Teamsters, seek to protect the safety of their members; however, bargaining has become increasingly difficult due to environmental pressure, including the impacts of North American Free Trade Agreement (NAFTA) provisions [75, 76]. Because of the degree of federal regulation, unions are often involved in bargaining over various issues [77], and are also involved in promoting prevention efforts [77]. Union membership appears to have a positive impact on driver safety, as union drivers help create safer trucking operations by contributing to a more stable and structured workplace environment [78]. This is related to the existence of master agreements between trucking companies and driver unions, which stipulate criteria for selection, training, and retention of drivers [78].

Areas of emphasis for truck driver health protection include reduced non-crash injuries and diesel exhaust exposure, as well as increased safety belt usage and improved ergonomics. In addition, female drivers have been identified as requiring special attention in health protection. The Teamsters Union has been at the forefront of many of these occupational health promotion and protection efforts, as many of the studies have included drivers from this union; further, the Teamsters have been heavily involved in rulemaking activities, participating in numerous Congressional hearings and including driver health and safety provisions in negotiations with trucking companies [79, 80].

Diesel Exhaust

Despite accumulating scientific data regarding the long-term harm of diesel exhaust exposure, OSHA has not established a standard for diesel exhaust as a unique hazard [81]. Nevertheless, measures have been undertaken to mitigate driver exposure to the carcinogenic properties of diesel exhaust, including minimizing the overall output by reducing truck idling. Truck idling in order to power all the truck cab's accessories (e.g., heat/air during periods of cold/hot weather) has been necessary in the past to ensure driver comfort and to facilitate adequate rest. Multiple alternatives have been explored within the trucking industry, including parking spaces with electrical connections, auxiliary power units, and detached heater or air conditioner units [82]. Electrified parking spaces, for example, have become more commonplace at truck stops across the country and provide drivers with temperature controls, electricity, Internet access, and satellite television [82]. A number of jurisdictions across the United States have passed laws limiting truck idling time [83]; however, without an alternative to provide comfort to drivers during periods of hot or cold weather, such restrictions only make their lives more difficult.

Safety Belt Usage

The use of safety belts is important in protecting the health of truck drivers, particularly in certain kinds of crashes such as rollovers, collisions with fixed objects, and collisions with other vehicles [72]. Safety belt usage has become a

priority in recent years for both federal agencies and the trucking industry [72]. A partnership was formed between government and trucking industry stakeholders called the FMCSA Safety Belt Partnership, designed to increase safety belt usage among professional drivers [72]. Unfortunately, the rigor in safety belt enforcement tends to vary wildly between companies [84]. Drivers have noted that, because the seat moves while driving but safety belts do not, this makes them uncomfortable to wear [84]. Issues such as the safety belt being made of material that is too hard, rubbing or vibrating against the neck or shoulder, locking, is too tight, and has limited range of motion have been cited by drivers as well [84]. Also, certain driver characteristics impact the frequency with which they use safety belts; for example, overweight and obese drivers are less likely to use them than drivers who are of normal weight [85], due to discomfort.

Non-Crash Injuries and Ergonomics

Non-crash injuries are a key focal point for driver health protection, as they are far more prevalent than injuries sustained from crashes [86]. OSHA has a limited role in protecting drivers against non-crash injuries, and training and safety management within companies have similarly fallen short in protecting drivers [72]. Although government activities have increased, industry groups and individual carriers are at the forefront of protecting drivers from these types of injuries [72]. Drivers are at risk of suffering an array of non-crash injuries, including those related to cranking dollies, sliding trailer tandems, pushing or pulling objects, being struck by cargo, and overexertion; however, slips and falls from and inside trucks are the primary source of non-driving injuries [72].

Poor ergonomics are partially to blame for non-crash injuries. For example, not all vehicles are properly designed for safe exit and entry [72]. Federal agencies have attempted to strengthen regulations with regard to ergonomics, but these efforts have been largely unsuccessful. In 2001, OSHA attempted to introduce a rule that sought to reduce repetitive strain injuries [87]; however, this rule was criticized as being ineffective and costly, and Congress repealed the rule the same year [87, 88]. Individual companies have also attempted to address ergonomic issues. Schneider National implemented a program which customized seat and steering wheel positions for each driver to minimize fatigue and maximize performance and comfort [9]. Evaluation of this initiative revealed reduced driver discomfort complaints and lost time as well as fewer workers' compensation injuries [9]. Ergonomic issues have been included in contract language as part of union negotiations and are stipulated in Article 18 of the National Master UPS Agreement and Article 16 of the National Master Freight Agreement [79, 80].

Female Drivers

Among the barriers to health that truck drivers must face is poor access to medical care while on the road [89]. Women have different health care needs than

men, and medical services available while on the road are often inadequate to meet these needs [90]. Female truck drivers report many chronic health conditions, along with many barriers and few supportive resources to enable treatment of these conditions [90]. Among the conditions that female drivers report are back pain, sinus and vision problems, migraines, and high blood pressure [90]. These issues are exacerbated by the fact that women generally enter the profession later in life, with one study indicating the mean age of entry at 46. Female drivers are therefore encountering the physical challenges of the profession at a time in their life beyond their physical peak, making them more vulnerable to the physical toll of trucking [90]. Female drivers generally either self-medicate or delay seeking treatment until they return home [90].

Another health protection issue for female drivers is safety. Women drivers have reported witnessing acts of violence, often in dangerous work environments that involve warehouses or terminals located in remote or depressed areas of cities or towns [19]. Although companies may emphasize their commitment to providing a safe work climate, female drivers report that locations outside of their organization's control, such as highway rest areas and truck stops, remain unsafe environments [91]. Perceptions of lack of safety add additional stress for female drivers and represent potential detriments to drawing more women into the industry [91].

Strategies for Improving Driver Health Protection

Many opportunities exist for improving driver health protection. Relationships from all stakeholders should be implemented and maintained, including employees and their families, labor unions, management, insurance companies and their staff, and state and federal government agencies [92]. Health protection interventions need to include an evaluation framework that emphasizes multiple forms of evaluation, including process and formative evaluation, with a focus on developing best practices and effective dissemination of findings [92]. Improving research methods can advance driver health protection as well. By integrating novel research methods into practices and operations within companies, insight can be gained as to how best to improve driver health protection [92]. Advancing research methods may include expanding data collection methods by advancing novel methods to fully understand the relationship between occupation and chronic disease and its various mechanisms [92]. For example, archival data could include a database of insurance claims, and assessment tools could be developed to appraise hazardous occupational exposures [92]. Such assessment tools could be used in conjunction with health risk appraisals to provide a comprehensive picture for both health protection and health promotion. Research should actively involve the employees themselves by utilizing a participatory research framework [92]. Further, a multidisciplinary, shared research agenda, with mechanisms to surmount barriers that exist between disciplines, should be advocated [92].

Diesel Exhaust

Diesel exhaust exposure can be reduced in several ways. First, truck exhaust outputs can be lowered by way of improved truck inspections that better reveal emissions problems in individual trucks. Second, trucks can be designed with greater fuel efficiency in mind, with the use of technological innovations, such as more effective filters that can be installed on truck air intake systems, for the purpose of reducing driver exposure to the negative effects of diesel exhaust. Third, idling restrictions can be expanded with the goal of reducing overall diesel exhaust output from trucks. It is important that this be accompanied by increased availability of alternative sources for in-cab temperature control (e.g., parking spaces with electrical connections, auxiliary power units, detached heater or air conditioner units).

Safety Belt Usage

Fortunately, truck cabs can be designed to foster safety belt use [72]; just as in private vehicles, dashboard lights and sounds continue to warn the driver to use the belts until they do so. Unfortunately, the ergonomics of safety belt design in commercial motor vehicles has been questioned, as drivers have complained that these belts rub or vibrate against necks/shoulders, lock, are uncomfortable, are too tight, and limit the driver's range of motion [93]. The ergonomics of safety belt design should be addressed to alleviate these concerns among drivers. Other interventions should focus on modifying the microenvironments within truck cabs to encourage drivers to use safety belts. Safety belts need to be designed to accommodate overweight and obese drivers by use of longer and wider belts, increasing drivers' likelihood of using them on a regular basis. Further, partnerships between stakeholders can be used to assure a more rigorous enforcement of safety belt usage, through a combination of incentives and fines.

Non-Crash Injuries and Ergonomics

Because there are many types of non-crash injuries, improving these outcomes necessitates several approaches. For one, safety training should emphasize the "three-point system," which teaches that three of the four extremities should be in contact with the ground, a step, or a handle at all times when entering and exiting vehicles and trailers in order to reduce slips and falls [72]. Truck cab designs should also be ergonomically sound and enhance driver safety when entering and exiting vehicles. Company policies should make footwear with slip-resistant soles mandatory for drivers to further reduce the rate of slips and falls. Drivers and supervisors should collaborate to create company policies that aim to reduce non-driving injuries; and drivers should be included in safety meetings with supervisors to help identify critical non-driving behaviors that lead to injury [72].

Female Drivers

To protect the health of female drivers, improved access to health care while on the road is vital [90]. This should include truck stop clinics that can accommodate the unique needs of female drivers, and should be supplemented with increased supportive resources such as websites and in-truck technology. Occupational health nurses need to be made more familiar with the health needs and issues faced by female drivers [90]. Additionally, suggested measures to increase safety for female drivers include improved lighting, emergency phones linked directly to nearest police precincts, strategically placed surveillance cameras, and 24-hour security (when feasible) at rest areas and truck stops [91].

Trucking Health Promotion Programs: Reviewing the Evidence

While the prevailing strategies to protect and improve the health of long-haul truckers in North America are insufficient in several respects, the primary focus of existing programs has been mainly on safety rather than on holistic and sustainable driver well-being [5, 9, 10]. Extant programs are individually based and focus on “lifestyle choices”; they are also mainly reactive and mostly rely on tertiary prevention to mitigate the impacts of poor driver health after the fact [5, 9]. Overall, trucking and warehousing companies are reluctant to provide substantial funding, and the few existing programs are mainly small-scale efforts with little chance to make the type of substantial impacts that are desperately needed [5]. Unfortunately, because of the high turnover rate in the trucking industry, investment in driver health with a long-term approach may not be viewed as worthwhile. Thus, these efforts are often fragmented and usually exist in “silos”; as a result, improvements are usually minimal, gaps exist between known best practices and what actions are actually undertaken in these efforts, and key stakeholders necessary who are needed to make a greater impact are not included in the process [9].

Trucker health is further impeded by the frequent lack of health insurance provision and healthcare access. Empirical data corroborate ample anecdotal evidence: 32.3 percent of drivers work without health insurance of any type and more than 50 percent are without employer-provided health insurance [11]; 62 percent of truckers who operate out of ports report having no insurance at all [94]. Even for insured drivers, finding health care while on the road is no small feat—over 40 percent of drivers acknowledged the poor availability of medical and dental services on the road, with 71.1 percent not having regular health-care visits, and 25 percent reporting difficulty in keeping appointments with healthcare professionals due to erratic work schedules [11]. Despite the desperate need for preventive care for drivers, the nature of the over-the-road trucking industry in North America makes provision of such opportunities exceedingly difficult, with drivers reporting that over 70 percent of trucking companies and over 80 percent of truck stops—where drivers spend the majority of their downtime—do not offer any type of health risk appraisals or wellness programs [11].

Substantial variation exists among current wellness programs for truckers. Programs vary in scope, with annual budgets ranging from \$150 to \$500,000, and also in longevity—programs range from being new to having been in place for up to 18 years, with an average age of 3.3 years [9]. Some companies offer small and simple programs, often addressing one area of concern: for example, Gordon Trucking, Inc., offers sleep apnea screening and treatment for its drivers, and Boyd Brothers Transportation, Inc., offers blood pressure machines and a workout facility on company premises through its Road2Health Program [95, 96]. For other companies, such as Con-way Freight and Schneider National, Inc., driver wellness programs are part-and-parcel of an overall healthy corporate culture [9], where drivers are viewed as the cornerstone of the company, driver health and wellness is a core value emanating from upper management, adequate resources are provided, and driver health and safety are inextricably linked [9]. While specific goals may vary from one company to the next, they usually center on: fighting against rising insurance premiums and health care and workers' compensation costs; reducing injuries, deaths, accidents, and absenteeism; a humanitarian concern for employee well-being; and, improving profits [9]. Wellness program components vary as well, as it is common practice for companies to adapt existing programs to match their particular needs or context [9], with weight management, nutrition education, health screenings, smoking cessation, exercise opportunities, and health information being some of the most common elements. Unfortunately, as descriptions of these programs mostly come from sources that are not peer-reviewed, they must be interpreted with caution.

Generally, companies that have instituted trucker wellness programs have found them to be worthwhile investments [9]. A sleep apnea treatment program at Schneider National has saved the company \$651 per driver in health-care costs since the program's inception in 2003 [9]. Trucks, Inc.'s individually tailored wellness program has resulted in a significant return-on-investment (ROI) since its inception [9]. JB Hunt, Inc., initiated a wellness program that included driver medical examinations and health coaching, resulting in a reduction in the number of workers' compensation claims, workers' compensation costs, accident rates, and driver turnover [9]. Analysis of Con-way Freight's wellness programs, which serve more than 8,000 employees, shows remarkable results: 80 percent reduction in workplace injuries, 32 percent reduction in workdays lost to injury, average weight loss of 11.1 pounds per participating employee, and reduction of blood pressure to below hypertensive status for 1,810 participating employees [67]. The curriculum of Con-way Freight's wellness program includes a health risk assessment, regular meetings with wellness coaches, incentive-based competitions, and stretching; with over 95 percent of employees completing their health risk assessments and over 80 percent regularly following up on their assessments [67]. Other trucking industry stakeholders have made programmatic efforts to enhance driver health as well. The Truckload Carriers Association, Healthy Trucker Association of America, and Lindora Clinic have initiated the Lean for Life

On-the-Road program, an online, 10-week rapid weight loss program [97]. TravelCenters of America/Petro has launched the *StayFit* program, offering nutritious food options, fitness rooms, walking trails, basketball hoops, and health information [97]. Finally, Pilot/Flying J has teamed up with Snap Fitness and Rolling Strong to open workout centers at travel plaza locations [97].

Toward Integrated Trucker Health Programs

The complexity of long-haul truckers' health crisis in North America is syndemic [3, 98], and the successes of conventional wellness programs have been modest overall due to their mostly reactive solution packages and their compartmentalized, vertical, or stand-alone approaches [5, 9]. As a result, new types of interventions—that are theoretically grounded in systems-science perspectives by simultaneously examining dynamic interrelationships of diverse factors with an emphasis on causal feedback processes—are imperative [92, 98]. To comprehensively and sustainably protect and promote trucker health and mitigate the ramifications of this unprecedented and urgent health crisis, interventions need to delve not only into trucker health behaviors, which are often the sole focus of existing programs, but also into those multi-level and interacting environmental barriers that have a serious bearing on such behaviors [11, 98].

The evolving and mutually reinforcing components of the proposed strategies—guided by the Integrated Trucker-Health Protection and Promotion (ITHPP) paradigm—would focus on improving the health-supportive capacity of trucking worksites, improving the health-sustaining capacity of communities in which truckers and their families live and through which truckers drive, and advancing health-promoting behavioral patterns of truckers [11]. The ultimate goals of such ITHPP programs would be to: 1) concurrently prevent injury and illness and advance the health, safety, productivity, and well-being of truckers and their families; 2) reduce the number of highway trucker-related accidents and thereby improve public safety; 3) control the fast-increasing rate of government and healthcare expenses due to highway accidents; and 4) improve trucking companies' bottom lines through fewer medical costs and worker compensation claims, higher productivity, and lower turnover. [99].

Within this framework, ITHPP programs would first and foremost delve into the key underlying causes of truckers' health problems—namely, excessive work hours and resultant fatigue, trucker payment systems that exacerbate trucker health problems and accidents, and scheduling and delivering pressures. In this context, ITHPP programs should simultaneously target: 1) trucking work environment stressors (e.g., lack of healthful workplace resources, mile-based pay, fragmented sleep patterns, team driving); 2) non-work-environment stressors (e.g., absence of social capital and institutional protections, absence of health insurance provision to drivers and their families); and 3) trucker health-risk behaviors (e.g., unhealthy diets, lack of exercise) [33, 92, 98]. For these ITHPP programs to be successful,

they must be highly synergistic and coordinated, by [5, 98]: 1) involving multiple stakeholders with inter-sectoral collaboration (e.g., government regulators, trucking unions and associations, trucking companies, shippers and retailers, health insurance firms); 2) integrating primary, secondary, and tertiary prevention and intervention measures and programs, such as risk assessments, risk and disease monitoring and surveillance, risk mitigation and management; 3) taking into account the multiple and interacting components of the trucker health system such as driver health, safety, well-being, and productivity; 4) identifying leverage points among drivers, trucking and warehousing companies, their customers, truck stops, government and corporate policies, and so forth; and 5) focusing simultaneously on a wide array of work-induced, interconnected risks such as smoking, diets, alcohol use, exercise, stress, back pains, work hours.

Finally, the implementation of ITHPP programs makes business sense, as they hold the potential for high return on investment (ROI) and provide corporations with ample opportunities to demonstrate social responsibility vis-à-vis drivers and other employees, corporate profits, and the broad environment. To have sustainable improvements in long-haul trucking in North America, portions of the money saved through increased productivity, reduced absenteeism and reduced highway accidents need to be invested back into these ITHPP programs.

CONCLUSION

Due mainly to a multi-level work context with substantial endemic risks, long-haul truckers in North America remain a highly underserved population with extraordinary health problems. Disproportionately high rates of fatigue as well as sleep and cardiometabolic disorders, in particular, often spill over to the general population in the form of highway accidents, with subsequent ramifications for governments, health systems, and trucking and warehousing companies' bottom lines. Due to the unique characteristics of the occupation (e.g., constant mobility of drivers), the implementation of proposed Integrated Trucker-Health Protection and Promotion programs in coordination with key stakeholders has the potential to sustainably advance the overall well-being of truckers and the general population, given that most of these risks are highly preventable and modifiable.

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NOTES

1. S. Dahl et al., "Hospitalization for Lifestyle Related Diseases in Long Haul Drivers Compared with Other Truck Drivers and the Working Population at Large," *Work* 33(3) (2009): 345-353, doi: 10.3233/wor-2009-0882.
2. A. J. van der Beek, "World at Work: Truck Drivers," *Occupational and Environmental Medicine* 69(4) (2012): 291-295, doi: 10.1136/oemed-2011-100342.
3. R. Olson et al., "A New Health Promotion Model for Lone Workers: Results of the Safety & Health Involvement for Truckers (SHIFT) Pilot Study," *Journal of Occupational and Environmental Medicine* 51(11) (2009): 1233-1246, doi: 10.1097/JOM.0b013e3181c1dc7a.
4. U.S. Bureau of Labor Statistics, *Workplace Safety and Health*, 2010, www.bls.gov/pub/mlr/2010/11/art3full.pdf (accessed October 9, 2012).
5. Y. Apostolopoulos, "Work Organization and the Epidemiology of Commercial Driving: From Monocausal to Multilevel Approaches," Center for Worker Health Seminar Series, Wake Forest University School of Medicine, Winston-Salem, NC, February 10, 2012.
6. Y. Apostolopoulos, A. A. Peachey, and S. Sonmez, "The Psychosocial Environment of Commercial Driving: Morbidities, Hazards, and Productivity of Truck and Bus

- Drivers,” in *Handbook of Stress in the Occupations*, eds. J. Langan-Fox J and C. Cooper (Northampton: Edward Elgar, 2011), 431-447.
7. G. P. Krueger et al., “Health and Wellness of Commercial Drivers,” in *The Domain of Truck and Bus Safety Research*, ed. A. Petty (Washington, D.C.: Transportation Research Board, 2007), 58-91.
 8. G. M. Saltzman and M. H. Belzer, “Truck Driver Occupational Safety and Health 2003: Conference Report and Selective Literature Review,” Truck Driver Occupational Safety and Health, Detroit, MI, April 24-25, 2003; re-published by U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, 2007.
 9. G. P. Krueger et al., “Health and Wellness Programs for Commercial Drivers,” in *Commercial Truck and Bus Safety* (Synthesis 15), 2007.
 10. G. P. Krueger, “Research on the Health and Wellness of Commercial Truck and Bus Drivers,” International Conference on Commercial Driver Health and Wellness, Washington, DC, November 8-10, 2010 (Transportation Research Board, 2012).
 11. Y. Apostolopoulos et al., “Health Survey of U.S. Long-Haul Truck Drivers: Work Environment, Physical Health, and Healthcare Access,” *113-Work* 46(1) (2013): 113-123, doi: 10.3233/WOR-121553.
 12. M. Belzer, *Sweatshops on Wheels: Winners and Losers in Trucking Deregulation* (New York: Oxford University Press, 2000).
 13. S. V. Burks et al., *Trucking 101: An Industry Primer* (Washington, D.C.: Transportation Research Board, 2010).
 14. Y. Apostolopoulos et al., “Active Living in the Trucking Sector: Environmental Barriers and Health Promotion Strategies,” *Journal of Physical Activity & Health* 9(2012): 259-269.
 15. Y. Apostolopoulos, L. Wideman, and S. Sonmez, Ongoing data collection, Trucker Sleep Study, University of North Carolina at Greensboro, Greensboro, NC, 2012.
 16. S. Shackelford and D. C. Murray, *Electronic On-Board Recorder Adoption in the Trucking Industry: Issues and Opportunities* (report issued by the American Transportation Research Institute), 2006.
 17. Owner-Operator Independent Driver Association, “Electronic On-Board Recorders (EOBRs),” http://www.ooida.com/OOIDA%20Foundation/Issues/EOBRs.asp#_ftn2 (accessed December 8, 2013).
 18. U.S. Department of Transportation, Federal Motor Carrier Safety Administration, “Summary of Hours-of-Service Regulations,” 2012, <http://www.fmcsa.dot.gov/rules-regulations/topics/hos/index.htm> (accessed November 10, 2012).
 19. M. Shattell et al., “Occupational Stressors and the Mental Health of Truckers,” *Issues in Mental Health Nursing* 31(9) (2010): 561-568, doi: 10.3109/01612840.2010.488783.
 20. Y. Apostolopoulos et al., “Environmental Determinants of Obesity-Associated Morbidity Risks for Truckers,” *International Journal of Workplace Health Management* 5(2) (2011): 4-38, doi: 10.1108/17538351211239162.
 21. U.S. Centers for Disease Control and Prevention, “Process for Providing Comment on NIOSH Survey of Truck Driver Safety and Health,” 2007, <http://www.cdc.gov/niosh/review/public/110/default.html> (accessed April 25, 2011).
 22. Y. Apostolopoulos et al., “Barriers to Truck Drivers’ Healthy Eating: Environment Influences and Health Promotion Strategies,” *Journal of Workplace Behavioral Health* 26(2011): 122-43, doi: 10.1080/15555240/2011.573754.

23. J. E. Anderson et al., "Obesity Is Associated with the Future Risk of Heavy Truck Crashes among Newly Recruited Commercial Drivers," *Accident Analysis & Prevention* 49(0) (2012): 378-384, doi: 10.1016/j.aap.2012.02.018.
24. A. J. Caban et al., "Obesity in U.S. Workers: The National Health Interview Survey, 1986 to 2002," *American Journal of Public Health* 95(9) (2005): 1614-1622, doi: 10.2105/AJPH.2004.050112.
25. P. Perry and B. L. Garratt, "Driver Health: Roadmap to Wellness" (unpublished white paper, 2010), "Roadside Medical Clinic," <http://roadsidemed.com/?=404;http://www.roadsidemed.com:80/Portals/0/Roadside%20%20ATA%20Driver%20Health.pdf&reqp=1&reqr=rKMiMKWzYzuupUDhpaSb> (accessed December 4, 2010).
26. D. F. Dinges and G. Maislin, Federal Motor Carrier Safety Administration, *Truck Driver Fatigue Management* (FMCSA-RRR-06-008), 2006.
27. U.S. Department of Transportation, National Highway Traffic Safety Administration, *An Analysis of Fatal Large Truck Crashes* (HS-809 569), 2003.
28. E. M. Wood et al., "Lifestyle Risk Factors in Commercial Drivers," in D. S. Bloswick, K. T. Hegmann, and R. F. Seseck, eds., *5th Annual Regional National Occupational Research Agenda (NORA) Young/New Investigators Symposium 2007* (University of Utah, Rocky Mountain Center for Occupational and Environmental Health), p. 155-164.
29. S. J. Benstowe, "Long Driving Hours and Health of Truck Drivers," (master's thesis, New Jersey Institute of Technology, 2008).
30. *Expert Panel Recommendations: Musculoskeletal Disorders and Commercial Motor Vehicle Driver Safety*, 2008, <http://www.fmcsa.dot.gov/rules-regulations/TOPICS/mep/report/MEP-Recommendations-Musculoskeletal%20v2-prot.pdf> (accessed December 3, 2013).
31. *Expert Panel Commentary and Recommendations: Licit Schedule II Drug Use and Commercial Motor Vehicle Driver Safety (Comprehensive Review)*, 2006, http://mcsa.fmcsa.dot.gov/Documents/Sept2013/SchII_Drug_Use_and_CMVdriver_safety.pdf (accessed December 3, 2013).
32. M. Shattell et al., "Trucking Organization and Mental Health Disorders of Truck Drivers," *Issues in Mental Health Nursing* 33(2012): 436-444, doi: 10.3109/01612840.2012.665156.
33. Michael Quinlan, "Organizational Influences of Truck-Driver Health: Reviewing the Evidence," International Conference on Commercial Driver Health and Wellness, Transportation Research Board and Federal Motor Carrier Safety Administration, Baltimore, MD November 8-10, 2010.
34. M. J. Dekker et al., "Salivary Cortisol Is Related to Atherosclerosis of Carotid Arteries," *Journal of Clinical Endocrinology & Metabolism* 93(10) (2008): 3741-3747, doi: 10.1210/jc.2008-0496.
35. G. Sorensen et al., "Work Experience and Tobacco Use: Findings from the Gear Up for Health Study," *Journal of Occupational and Environmental Medicine* 51(1) (2009): 87-94, doi: 10.1097/JOM.0b013e31818f69f8.
36. J. Hedlund and D. Blower, *Large Truck Crash Causation Study (LTCCS) Analysis Series: Using LTCCS Data for Statistical Analyses of Crash Risk* (FMCSA-RI-05-037), 2006.
37. M. Belzer, *Report of Analysis: Truck Crashes and Work-Related Factors Associated with Drivers and Motor Carriers* (DTRS57-04-D30043), 2009, <http://www.rsrt.govau/>

- default/assets/File/Subs_on_draft_RSRO_TWU/exhibits/MB%201.2009.Belzer.pdf (accessed April 12, 2013).
38. D. Weigand, R. Hanowski, and S. McDonald, *Commercial Motor Vehicle Health and Fatigue Study* (09-UF-002), 2009.
 39. U.S. Department of Labor, Bureau of Labor Statistics, "Heavy and Tractor-Trailer Truck Drivers," 2012, <http://www.bls.gov/ooh/transportation-and-material-moving/heavy-and-tractor-trailer-truck-drivers.htm> (accessed September 8, 2012).
 40. Yorghos Apostolopoulos and Sevil Sonmez, "Tracing the Diffusion of Infectious Diseases in the Transport Sector," in *Population Mobility and Infectious Disease*, eds. Yorghos Apostolopoulos and Sevil Sonmez (New York: Springer, 2007), 131-156.
 41. Y. Apostolopoulos and S. Sonmez, *Trucker Networks, Drug Use, and Transmission of Sexually Transmitted and Bloodborne Infections: Preliminary Findings from the First Epidemiological Investigation in North America*, 2006.
 42. B. Lichtenstein et al., "HIV Risk among Long-Haul Truckers in the USA," *Culture, Health & Sexuality* 10(1) (2008): 43-56, doi: 10.1080/13691050701582936.
 43. D. Stratford et al., "Highway Cowboys, Old Hands, and Christian Truckers: Risk Behavior for Human Immunodeficiency Virus Infection among Long-Haul Truckers in Florida," *Social Science & Medicine* 50(5) (2000): 737-749, doi: 10.1016/S0277-9536(99)00335-4.
 44. D. Stratford, T. V. Ellerbrock, and S. Chamblee, "Social Organization of Sexual-Economic Networks and the Persistence of HIV in a Rural Area in the USA," *Culture, Health & Sexuality* 9(2) (2007): 121-135, doi: 10.1080/13691050600976650.
 45. Y. Apostolopoulos, S. Sonmez, and K. Massengale, "Mapping U.S. Long-Haul Truck Drivers' Multiplex Networks and Risk Topography in Inner-City Neighborhoods," *Health & Place* (in Review).
 46. S. Valway et al., "Risk Assessment and Screening for Sexually Transmitted Infections, HIV, and Hepatitis Virus among Long-Distance Truck Drivers in New Mexico, 2004-2006," *American Journal of Public Health* 99(11) (2009): 2063-2068, doi: 10.2105/AJPH.2008.145383.
 47. U.S. Centers for Disease Control and Prevention (Volume 23), *HIV Surveillance Report 2011*, 2012 http://www.cdc.gov/hiv/pdf/statistics_2011_HIV_Surveillance_Report_vol_23.pdf (accessed December 13, 2013).
 48. U.S. Centers for Disease Control and Prevention, *Viral Hepatitis Surveillance United States 2011*, 2012 <http://www.cdc.gov/hepatitis/Statistics/2011Surveillance/PDFs/2011HepSurveillanceRpt.pdf> (accessed December 13, 2013).
 49. U.S. Centers for Disease Control and Prevention, *Sexually Transmitted Disease Surveillance 2011*, 2012, <http://www.cdc.gov/STD/stats11/Surv2011.pdf> (accessed December 13, 2013).
 50. U.S. Environmental Protection Agency, *Study of Exhaust Emissions from Idling Heavy-Duty Diesel Trucks and Commercially Available Idle-Reducing Devices*, 2002, www.epa.gov/smartway/documents/epaidlingtesting.pdf (accessed November 21, 2012).
 51. P. Gilman, *Health Assessment Document for Diesel Engine Exhaust* (EPA/600/8-90/057F), 2002.
 52. F. Laden et al., "Cause-Specific Mortality in the Unionized US Trucking Industry," *Environmental Health Perspectives* 115(8) (2007): 1192-1196, doi: 10.1289/ehp.10027.

53. American Lung Association, "Heavy Diesel Exhaust Linked to Lung Cancer," 2012, <http://www.lung.org/about-us/our-impact/top-stories/in-the-news/heavy-diesel-exhaust-lungcancer.html> (accessed November 23, 2012).
54. T. J. Smith et al., "Overview of Particulate Exposures in the US Trucking Industry," *Journal of Environmental Monitoring* 8(7) (2006): 711-720, doi: 10.1039/b601809b.
55. M. Matsuoka et al., *Global Trade Impacts: Addressing the Health, Social, and Environmental Consequences of Moving International Freight Through our Communities*, 2011.
56. R. Balarajan and M. E. McDowall, "Professional Drivers in London: A Mortality Study," *British Journal of Industrial Medicine* 45(7) (1998): 483-486, doi: 10.1136/oem.45.7.483.
57. R. D. Brook et al., "Particulate Matter Air Pollution and Cardiovascular Disease: An Update To the Scientific Statement from the American Heart Association," *Circulation* 121(21) (2010): 2331-2378, doi: 10.1161/CIR.0b013e3181d8bec1.
58. A. Peters et al., "Increased Particulate Air Pollution and the Triggering of Myocardial Infarction," *Circulation* 103(23) (2001): 2810-2815.
59. E. A. Finkelstein, S. M. Burgess, and B. C. Hale, "The Costs of Obesity in the Workplace," *Journal of Occupational and Environmental Medicine* 52(10) (2010): 971-976, doi: 10.1097/JOM.0b013e3181f274d2.
60. International Agency for Research on Cancer, World Health Organization, "IARC: Diesel Engine Exhaust Carcinogenic," [press release], http://www.iarc.fr/en/media-centre/pr/2012/pdfs/pr213_E.pdf (accessed January 14, 2014).
61. Pan American Health Organization, "Diesel Engine Exhaust Carcinogenic," 2012, http://new.paho.org/hq/index.php?option=com_content&view=article&id=6985&Itemid=1926 (accessed November 10, 2012).
62. E. Garshick et al., "Lung Cancer and Vehicle Exhaust in Trucking Industry Workers," *Environmental Health Perspectives* 116(10) (2008): 1327-1332, doi: 10.1289/ehp.11293.
63. American Cancer Society, "Diesel Exhaust," 2012, <http://www.cancer.org/cancer/cancercauses/othercarcinogens/pollution/diesel-exhaust> (accessed December 10, 2012).
64. B. Jrvholm and D. Silverman, "Lung Cancer in Heavy Equipment Operators and Truck Drivers with Diesel Exhaust Exposure in the Construction Industry," *Occupational and Environmental Medicine* 60(7) (2003): 516-520, doi: 10.1136/oem.60.7.516.
65. K. Steenland, J. Deddens, and L. Stayner, "Diesel Exhaust and Lung Cancer in the Trucking Industry: Exposure-Response Analyses and Risk Assessment," *American Journal of Industrial Medicine* 34(3) (1998): 220-228, doi: 10.1002/(SICI)1097-0274(199809)34:3<220::AID-AJIM3>3.0.CO;2-Z.
66. B. C. Martin et al., "The Impact of Overweight and Obesity on the Direct Medical Costs of Truck Drivers," *Journal of Occupational and Environmental Medicine* 51(2) (2009): 180-184, doi: 10.1097/JOM.0b013e3181965d6e.
67. A. Osland et al., *Wellness Lessons from Transportation Companies* (MTI Report WP 11-01), 2011.
68. Cottingham and Butler, "Trucking Compensation and Benefits Benchmark Survey," 2010, <http://www.truckingsurvey.com/surveyquestions.html> (accessed December 18, 2012).

69. CPA Trucking Industry Specialist, "Remarks to the FMCSA MCSAP Leadership Conference" (by FMCSA Administrator A. S. Ferro, Rosemont, IL, April 11, 2011), 2011, <http://www.cpatrucking.com/remarks-to-the-fmcsa-mcsap-leadership-conference.html> (accessed May 2, 2011).
70. U.S. Department of Labor, Occupational Safety & Health Administration, "Trucking Industry," https://www.osha.gov/SLTC/trucking_industry/ (accessed July 24, 2013).
71. U.S. Department of Labor, Occupational Safety & Health Administration, "State Occupational Safety and Health Plans," <https://www.osha.gov/dcsp/osp/index.html> (accessed July 24, 2013).
72. R. R. Knipling, *Safety for the Long-Haul: Large Truck Crash Risk, Causation & Prevention* (Arlington: the American Trucking Associations, Inc., 2009).
73. U.S. Department of Labor, Occupational Safety & Health Administration, "SEC. 4. Applicability of This Act," https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=OSHACT&p_id=3358 (accessed December 8, 2013).
74. "Industries at a Glance: Transportation and Warehousing: NAICS 48-49," <http://www.bls.gov/iag/tgs/iag48-49.htm> (accessed December 11, 2012).
75. Industrial Workers of the World, "Motor Transport Workers Industrial Union 530," <http://www.iww.org/unions/dept500/iu530> (accessed July 24, 2013).
76. M. H. Belzer, "Trucking: Collective Bargaining Takes a Rocky Road," in *Collective Bargaining in the Private Sector*, eds. P. F. Clark, J. T. Delaney, A. C. Frost (Champaign: Industrial Relations Research Associations, 2002), p. 311-342.
77. H. Moss, L. Kincl, and C. O'Neill, *Health Promotion Programs and Unions*, 2008 <http://pages.uoregon.edu/lerc/public/pdfs/healthpromotion.pdf> (accessed December 11, 2012).
78. T. M. Corsi et al., "Safety Performance Differences between Unionized and Non-Union Motor Carriers," *Transportation Research Part E: Logistics and Transportation Review* 48(4) (2012): 807-816, doi: 10.1016/j.tre.2012.01.003.
79. National Master Freight Agreement for the Period April 1, 2008 thru March 31, 2013. International Brotherhood of Teamsters, 2008.
80. National Master United Parcel Service Agreement for the Period December 19, 2007 thru July 31, 2013. International Brotherhood of Teamsters, 2007.
81. U.S. Department of Labor, Occupational Safety & Health Administration, "Diesel Exhaust," <https://www.osha.gov/SLTC/dieselexhaust/> (accessed July 24, 2013).
82. E. Gies, "Putting US Trucking on a Diet," *The New York Times*, May 19, 2009, <http://www.nytimes.com/2009/05/19/business/global/19rentruck.html> (accessed June 4, 2012).
83. F. Kiel, "Truck Idling Limits Increasing Nationwide as More Jurisdictions Pass Rules, ATRI Says," *Transport Topics* (3760) (2007): 4.
84. G. Bergoffen et al., *Synthesis Report #8: Commercial Motor Vehicle Driver Safety Belt Usage* (Washington: Transportation Research Board, 2005).
85. D. Weigand et al., *Fatigue Analyses from 16 Months of Naturalistic Commercial Motor Vehicle Driving Data* (08-F-001), 2008.
86. V. Dick, J. Hendrix, and R. R. Knipling, "New Hours-Of-Service Rules: Trucking Industry Reactions and Safety Outcomes," *Transportation Research Record: Journal of the Transportation Research Board* 1966(1) (2006): 103-109, doi: 10.3141/1966-13.
87. M. Davis, "Trucking Association, Industry Applaud Repeal of OSHA Ergonomics Rule," *Bulk Transporter*, 2001, <http://bulktransporter.com/archive/industry-applaud-repeal-osh-ergonomics-rul> (accessed December 12, 2012).

88. A. Spognardi and S. L. Ketay, "Perspective—Bad Law and Bad Politics: OSHA's Ill-Fated Ergonomics Standard," *Employee Relations Law Journal* 27(1) (2001): 85-90, doi: 216.36.221.44/.
89. A. J. Solomon et al., "Healthcare and the Long Haul: Long Distance Truck Drivers—A Medically Underserved Population," *American Journal of Industrial Medicine* 46(5) (2004): 463-471, doi: 10.1002/ajim.20072.
90. D. B. Reed and Jennifer S. Cronin, "Health on the Road: Issues Faced by Female Truck Drivers," *AAOHN Journal: Official Journal of the American Association of Occupational Health Nurses* 51(3) (2003): 120-125.
91. T. M. Bernard, L. H. Bouch, and W. S. Young, "Stress Factors Experienced by Female Commercial Drivers in the Transportation Industry," *Professional Safety* 45(9) (2000): 20-26.
92. G. Sorensen et al., "Preventing Chronic Disease in the Workplace: A Workshop Report and Recommendations," *American Journal of Public Health* 101(S1) (2011): S196-S207, doi: 10.2105/AJPH.2010.300075.
93. Federal Motor Carrier Safety Administration, *Commercial Motor Vehicle Driver Safety Belt Usage* (FMCSA-MCRRR-07-010), 2007, <http://www.fmcsa.dot.gov/facts-research/research-technology/tech/CMV-Driver-Safety-Belt-Usage-feb-2007.pdf> (accessed January 14, 2014).
94. J. Lin and A. Prakash, *Taking a Toll: the High Cost of Health, Environment, and Worker Impacts of the Oakland Port Trucking System*, 2009.
95. "Gordon Trucking Begins Sleep Apnea Wellness Program with REM Medical Corp.," 2009, <http://respiratory-care-sleepmedicine.advanceweb.com/Article/Gordon-Trucking-Begins-Sleep-Apnea-Wellness-Program-with-REM-Med.aspx> (accessed December 12, 2012).
96. "Employee Benefits-Road2Health Wellness Program," http://www.boydbros.com/wellness_program.html (accessed December 9, 2012).
97. A. Ellin, "A Hard Turn: Better Health on the Highway," *The New York Times*, December 17, 2011, http://www.nytimes.com/2011/11/22/health/a-hard-turn-truck-drivers-try-steeringfrom-bad-diets.html?pagewanted=all&_r=1& (accessed June 4, 2012).
98. Y. Apostolopoulos et al., "How Prevention Science Can Benefit from Complexity Science: A Roadmap to a Healthy Work Environment Paradigm for Transport Workers," *Global Health Promotion* (in press).
99. Y. Apostolopoulos, "Transportation Health Services," 2012, <http://www.transportationhealth.net/what-we-do> (accessed December 21, 2012).

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